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In vitro Effect of APF and Neutral NaF on Surface Roughness of Two Composite Resins

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Abstract: The purpose of this *in vitro* study was to compare the surface roughness of two different composite resin restorations (Heliomolar and Supreme) following treatment by three fluoride components of APF, Neutral NaF Gel and foam. APF (1.23%) and Neutral NaF in the form of gel and foam were selected and the tested composites were Supreme and Heliomolar. Twenty cylindrical specimens were made from each composite and randomly divided into 20 groups. After 48 h of storage in distilled water, the composites were subjected to the fluoride treatments so that the total number of applications became equal to 1 year fluoride treatment regimen (4 min/6 months). The control groups were not subjected to the fluoride treatments and were kept in distilled water. Then all specimens were assessed by Scanning Electron Microscopy (SEM). In the second stage, another twenty cylindrical specimens were made in the same manner and each specimen was weighed on a scale with 0.0001 precision. The specimens were again weighed accordingly both after the first and second fluoride applications. The SEM observations were evaluated by calculating Kappa agreement index. Agreement could not be calculated except for APF foam group. The data of second stage showed no significant differences among three groups.

Key words: Fluoride, composite, surface roughness, weight loss, APF Gel, Iran

INTRODUCTION

Professional fluoride application is an effective method of preventing dental caries by increasing the resistance of hard tooth structure. Fluoridation of the community water supply is one of the most effective yet cost-effective methods of fluoride therapy. However, this method is not the best way to achieve desirable results because of the lack of control in receiving fluoride by different ages of the population. Therefore, the use of topical fluoride application, such as toothpastes, mouth washes and fluoride gels, seems to have received more confirmation and effectiveness on controlling tooth decay (Warren and Chan, 1997). The results of *in vitro* studies have indicated that various topical fluorides may etch or react with porcelain, glass ionomer, fissure sealant and composite restorative materials (Warren and Chan, 1997; Windeler, 2004; Shashikiran *et al*., 2003; Kula *et al*., 1996). Hydrofluoric acid which is component of APF preparations have a destructive effect on composite restorations and causes weight loss, wear and lost integrity (Papagiannoulis *et al*., 1997; Bishara *et al*., 2002; Akkaya *et al*., 1996).

Electron microscope studies have shown that changes in composite restorations which have been affected by APF depends on the amounts of the fillers or the composition of the fluoride gel. The most destructive effect will happen when there is more acid in the composition of the fluoride gel and also when the filler of the composite is Barium Alumina Silicate Glass (Papagiannoulis *et al*., 1997; Kula *et al*., 1986, 1996). It is important to know application of which type of fluoride for high risk children in dental caries have less destructive effects on their composite restorations. This study evaluated the *in vitro* effect of two different fluoride gel and foam (APF, Neutral NaF) on the two currently used composite restorative materials (Supreme and Heliomolar) for restoration or protection of children's teeth.

MATERIALS AND METHODS

Ten plastic molds with a hole (6 mm diameter and 2 mm thick) was prepared. Two specimens of composite (10 Supreme and 10 Heliomolar) (Lickhten Stein, Switzerland) were condensed into the holes. Both sides of the composites were light cured (each side 40 sec) according to manufactures directions. Therefore, 20 columns were made from two different campsites. Upon removing from the mold each sample was polished with four polishing Soft-lex disks which have been arranged in superfine, fine, medium and course (3M Dental Products, St Paul, MN55144, USA) and low speed hand piece for 10

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times in one direction. Then they were washed, dried carefully and put in 20 mL coded plastic dishes. The control samples were stored in distilled water at room temperature. The study samples were dried, weighted and suspended 4 min in fluoride solution (Sullivan, Schein Dental, Melville, NY, USA) as a normal method of fluoride therapy every 6 months. The specimens washed with distilled water, reweighted and in order to prevent chemical equilibrium around the material surface and create intermediate relaxation they were kept in distilled water for 30 min (Papagiannoulis *et al*., 1997). In order to follow the annual treatment regimen the fluoride therapy was repeated once more.

Scanning Electron Microscopy (SEM) study was done by DSM 940-A (ZEIS, Germany). Each specimen was scanned from two aspects and with six different magnifications (10000-500000). Finally, 240 micrographs and 240 photographs were prepared. Micrographs were examined two times within two different days by two observers. These observers were educated for examining the surface roughness of specimens individually and were blind. In every inspection one series of micrographs were put beside each other and any visible destruction on composite surface was ranked according to the following standards; absence of surface roughness, moderate roughness and gross roughness.

Micrographs were inspected blindly for the third time with the same manner by the three observers and were ranked again according to the above mentioned standards. The results were recorded separately. At the second stage, 20 specimens of composite were prepared with the same method and stored in the plastic dishes of 20 mL. Then every specimen was weighed with a scale with sensitivity of 0.0001 g and recorded. The process was repeated once more and re-weighted. The control samples subjected to the same regimen, except they were immersed in distilled water rather than fluoride and then weighted. Data resulted from the first stage of study (SEM observations) were analyzed by means of Kappa agreement index and for the second stage by ANOVA. All the analysis was done after proving the equality of variants with Levene's test and the normality of distribution with Kolmogorov-Smirnov test. Probabilities of <0.05 were accepted as significant.

RESULTS AND DISCUSSION

Evaluation of the SEM photographs taken from samples of each group revealed that the APF Gel had a more visible destructive effect on the restorative material. This is shown in Fig. 1 where APF Gel was applied to the Heliomolar restoration material in comparison to Fig. 2

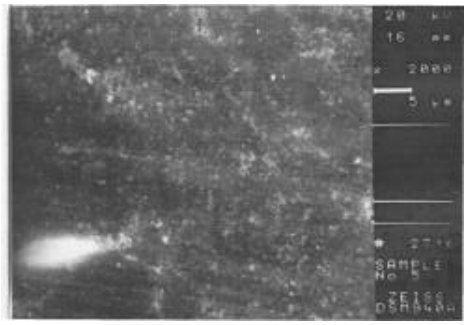

Fig. 1: SEM view of the Heliomolar restoration after APF Gel application

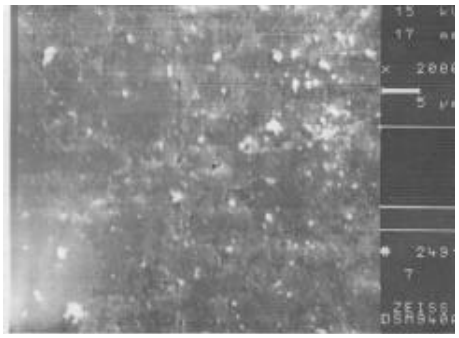

Fig. 2: SEM view of the Heliomolar restoration after NaF Gel application

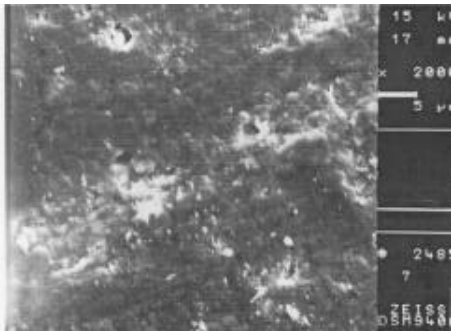

Fig. 3: SEM view of the Supreme restoration after APF Gel application

which was subjected to NaF Gel. Similar effect was observed on Supreme material with the latershowing even a more destruction with the APF Gel (Fig. 3 and 4). Application of APF Foam showed more or less the same effect on the materials.

The Kappa index regarding the opinion of two observers in the first and second stage was the same 0.024. As $\alpha = 0.923$, the measure of agreement was not statistically significant. It was found that the two observers had the similar opinion about APF gel specimen

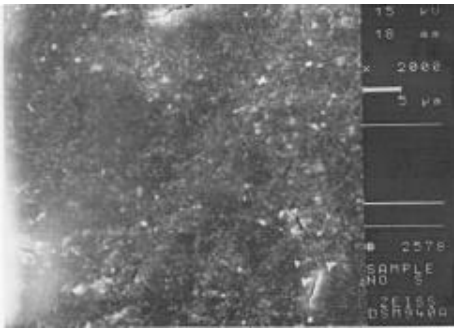

Fig. 4: SEM view of the Supreme restoration after NaF Gel application

in the first stage with the Kappa index, 0.026. This indicated that the observed agreement was much lower than expected. Furthermore, the opinion regarding APF foam specimens in the second stage were the same and the kappa index was 0.385. The measure of agreement was not statistically significant ($\alpha = 0.149$). As the opinion of the two observers on the other cases was not similar,the researchers could not calculate the Kappa agreement index.

Analysis of the index of agreement among the three observers with observer no. 1, 2 and 3, it was found that the opinion of observer no. 2 and group assembly (Gold standard) on Neutral NAF foam specimens was equal and the kappa index was nil. That means observer agreement was equal to the expected agreement ($\alpha = 1$). The observer no. 1 had the similar opinion with the group assembly about APF Foam specimens with the Kappa index 0.619 and $\alpha = 0.006$, the agreement was statistically significant. Because $0.6<\kappa<0.8$, this agreement was good. Kappa agreement index could not be calculated for the other cases as the opinion of observer no. 1 and 2 was not similar to the gold standard. Regarding the second stage of study, the researchers found no differences in the first ($\alpha = 0.708$), second ($\alpha = 0.378$) and the third weight ($\alpha = 0.707$) among the 5 groups.

SEM study of polished composite resins because of exposure to APF indicated surface roughness APF have sodium fluoride and phosphoric acid in their composition which can easily available to the tooth surface or restorations. Filler particles are the most likely site of degradation as was seen in the micrographs (Kula *et al*., 1986). This study indicated that the adverse effect of APF were directly related to the size and type of its filler. Additional evidence for degradation of filler particles by APF gel is shown by Bowen and Reed who observed the etching effect of acids on various experimental formulations of glass fillers (Warren and Chan, 1997; Papagiannoulis *et al*., 1997; Bishara *et al*., 2002; Akkaya *et al*., 1996). HF can etch glass in the mouth temperature while phosphoric acid can do this in a higher temperature (Akkaya *et al*., 1996). As the increase in surface roughness may result in plaque accumulation on the restoration, staining of the surface, gingivitis and composite destruction. It should be taken into consideration that the critical surface roughness for bacterial accumulation and colonization on the surface of restorations is 0.2 μm (Soeno *et al*., 2002). Various studies have shown that using APF increases surface roughness of some composite materials (Papagiannouslis *et al*., 1997; Yip *et al*., 2004) and due to this using Neutral NaF has been suggested to solve this problem (Yip *et al*., 2004; Kula *et al*., 1992, 1996, 1997; Diaz-Arnold *et al*., 1995; Yap and Mok, 2001; El-Badrawy and McComb, 1998). The effect of APF on composite with glass particles especially Barium Boro Aluminium silicate glass is more than other types (Yip *et al*., 2004; El-Badrawy and McComb, 1998; Kula *et al*., 1983, 1986). SEM observations have shown that macro and submicron mineral fillers are strongly affected by APF. On the other hand, APF has the lowest effect on microfilled material (Papagiannouslis *et al*., 1997). Papagiannoulis *et al*. (1997) has shown the detachment of fillers and selected dissolution of Barium particles as the effect of APF by using SEM, FTIR Spectroscopy and x-ray Microanalysis. It was found that Heliomolar composite had the lowest destruction when APF was applied. Pre-polymerized fillers had no changes and the connectivity between filler and resin had been kept. His important finding was that ytterbium trifluoride had 5.3% reduction in its volume particles that probably show the hydrolytic destruction of the particles. So it can be concluded that even micro filled composites can not be protected against the adverse effects of 1.23% APF gel (Papagiannouslis *et al*., 1997).

In the present study, some changes were observed on Heliomolar composite surface due to the effect of APF Gel. However no quantitative information is exists in this regard and more studies are mandatory. In addition, the micrographs of APF gel group were examined and compared with Neutral NaF group. Some changes were observed on the surface of group one specimens but further analyses were not possible as it couldn't evaluate Kappa index in all cases. Recently application of fluoride foam has been recommended because of its formulation, physical shape and molecular structure. It has been suggested that can penetrate better into the enamel surface and its physical form results in less swallowing of fluoride by patients while has less amount of fluoride ions in the same amount compared to gel (Sposetti *et al*., 1986; Abate *et al*., 2001). APF foam has 2.14% NaF and 23% hydrofluoric acid that both can dissolve composite materials (Abate *et al*., 2001). Garcia-Godoy *et al*. (2003) in

two studies examined the effect of APF foam on compomers and different glass-ionomers by means of profilometer and SEM study. They could not find better results compared to the effect of APF gel on the earlier mentioned materials. Although, surface roughness was visually evident, Profilometer did not show obvious effects after 1 and 4 min application of foam (Abate *et al*., 2001; Garcia-Godoy *et al*., 2003; Cehreli *et al*., 2000). In the present study, Kappa index could not be calculated in some cases, so in general, the researchers suggest quantitative measuring of surface roughness.

Some researchers found that APF can cause specific reduction of weight in resin-base composites. This reduction was confirmed by SEM, in losing filler particles (Kula *et al*., 1996; El-Badrawy and McComb, 1998). In another study, they showed that the destruction of composite surface was depended on size and type of filler particles. Strontium glass-filled composites had obviously more weight loss and more surface roughness. This amount was less in silica-filled or quartz-filled composite (Kula *et al*., 1986). Difference in the decrease of composite weight with different gels may result from the difference in PH and fluoride concentration of gels (Yip *et al*., 2004). In the present study, weight reduction of Heliomolar and Supreme composites after APF and Neutral NaF Gel and foam were examined separately. Although, after the first application of fluoride changes were seen in weight which is probably due to water absorption. No statistically significant weight reduction was found after the second application. Surface roughness was found to some extent in APF Gel applied cases with little evidence of such changes in the application of NaF Gels. However, this finding was not statistically significant.

CONCLUSION

The results of the present study showed that the effect of fluoride (APF and Neutral NaF) on the surface roughness of composite restorations can not be evaluated with SEM and observation alone and it is better to use quantitative methods.

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